TETRA TECH

UAF Light Detection and Ranging (LiDAR) and Ortho-Imagery Data Project Report Wrangell Corridor

Tetra Tech was contracted by the University of Alaska Fairbanks (UAF) to provide LiDAR and ortho-imagery data for the Road to Resources in Alaska Program. Tetra Tech collected LIDAR data and aerial imagery during the fall of 2013 and the spring/summer of 2014. Included within this document are the various reports required by the contract.

Collection Report

LiDAR data for the Wrangell corridor project area was acquired with a Cessna 401 aircraft. The tail number of this aircraft is N34MM.

LiDAR Sensor:
Optech Orion H300

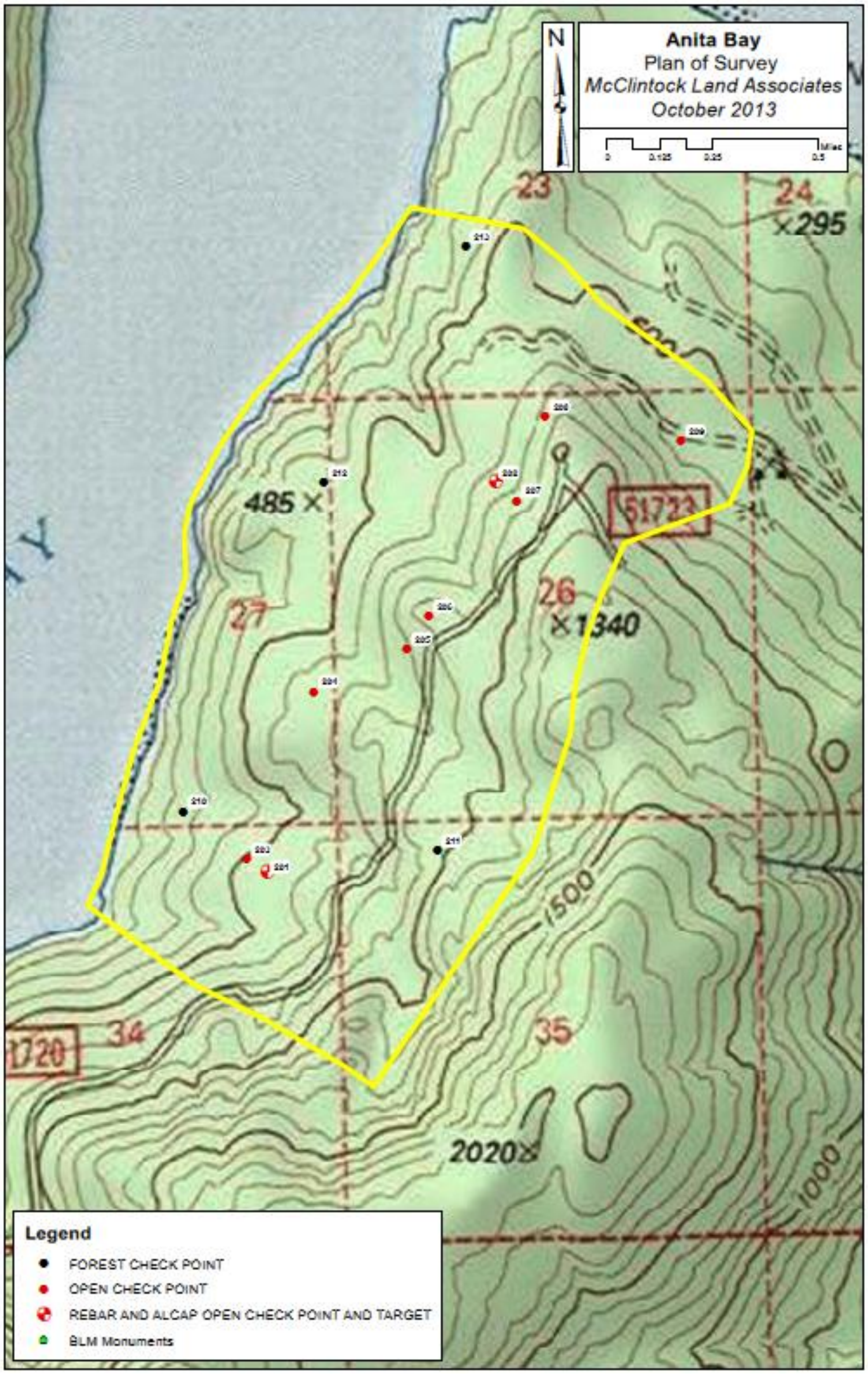
Imagery for the Wrangell corridor project area was acquired with a Piper Aztec PA-23-250 Turbo twin aircraft. The tail number of this aircraft is C-FKSK.

Imagery Camera:
Microsoft Vexcel UltraCam Eagle

Survey Report

Each polygon area contains calibration points as well as independent check points. Check points have been withheld from Tetra Tech. The coordinates with field notes for each area will be provided to GINA directly by the surveyor, McClintock Land Associates.

The Wrangell area contains 3 calibration points and 10 independent check points as shown in the diagram below.



Certification from Surveyor

TIN CERTIFICATION

Date Prepared: 9/19/2014

Roads to Resources – WRANGELL – Model Key Points TIN

Prepared by: McClintock Land Associates, Inc.
Prepared for: Tetra Tech, Inc.

I hereby certify that an independent ground survey was performed under my supervision to obtain sampling data to be used to test the reliability of the electronic Triangular Irregular Network (TIN) surface model for Wrangell, Alaska. This TIN is based on the Model Key Points Method. For ease of manipulation the surface model was divided into 32 cells as defined in the following .dwg files:

Dated 9/12/2014
L29575_16075-Surface-MKP.dwg
L29575_16100-Surface-MKP.dwg

Dated 9/15/2014
L29600_16050-Surface-MKP.dwg
L29600_16075-Surface-MKP.dwg
L29600_16100-Surface-MKP.dwg
L29625_16050-Surface-MKP.dwg
L29625_16075-Surface-MKP.dwg
L29625_16100-Surface-MKP.dwg
L29650_16025-Surface-MKP.dwg
L29650_16050-Surface-MKP.dwg
L29650_16075-Surface-MKP.dwg
L29675_16000-Surface-MKP.dwg
L29675_16025-Surface-MKP.dwg
L29675_16050-Surface-MKP.dwg
L29700_16025-Surface-MKP.dwg

Dated 9/15/2014
L29700_16050-Surface-MKP.dwg
L29700_16075-Surface-MKP.dwg
L29725_16025-Surface-MKP.dwg
L29725_16050-Surface-MKP.dwg
L29725_16075-Surface-MKP.dwg
L29750_16025-Surface-MKP.dwg
L29750_16050-Surface-MKP.dwg
L29750_16075-Surface-MKP.dwg
L29775_16025-Surface-MKP.dwg
L29775_16050-Surface-MKP.dwg
L29775_16075-Surface-MKP.dwg
L29800_16000-Surface-MKP.dwg
L29800_16025-Surface-MKP.dwg
L29800_16050-Surface-MKP.dwg
L29825_16000-Surface-MKP.dwg
L29825_16025-Surface-MKP.dwg
L29825_16050-Surface-MKP.dwg

These files were produced by Tetra Tech, Inc. from a LiDAR survey. The LiDAR data was acquired and calibrated by Aerial Surveys International on June 16, 2014 and processed by Tetra Tech, Inc. between July 11 and September 12, 2014.

The independent ground survey was performed by McClintock Land Associates, Inc. on May 2, 2014 using Static and RTK GPS methods as well as conventional optical methods. Topcon FC-250 & FC-236 Data Collectors, along with Topcon HiPer GA and GR-3 GNSS receivers were used as well as a Topcon GPT-3005LW Reflectorless Electronic Total Station. Topcon Magnet Field v2.0.1 data collection software was used for the field data collection and Topcon Magnet Office Tools v2.0.1 office software was used for post-processing and adjustments.

TIN CERTIFICATION

Roads to Resources – WRANGELL – Model Key Points TIN

The survey data was collected in Alaska State Plane Coordinates, Zone 1 (NAD83) in US Survey Feet. The vertical datum is NAVD88 in feet and elevations were determined as approximate orthometric heights using Geoid Model 2012A. Ties to the NSRS were made using the NGS OPUS Utility. A more detailed description of the methods and control will be contained in the Survey Report for this project.

This TIN was checked with a total of 9 independent QC check points which had been withheld from the TIN producer. The RMS error between the elevations returned from the TIN and the actual check points was 0.09 feet. This meets the standard for ASPRS Class 2 Maps for Vertical Accuracy for a 2 foot contour interval map.

STATE OF ALASKA
49TH
William McClintock
WILLIAM McCLINTOCK
LS 5480
9-19-14
REGISTERED PROFESSIONAL LAND SURVEYOR

William McClintock
Professional Land Surveyor
McClintock Land Associates, Inc.

9-19-2014
Date

TETRA TECH

QA/QC Report

Tetra Tech has performed quality control throughout each step of the acquisition and processing for the Wrangell corridor project area. The only difficulty encountered was during the acquisition phase of the project, waiting for suitable weather conditions for collection. Difficult weather conditions were a challenge and caused delays and offsets between LiDAR acquisition, image acquisition and ground survey. Our flight teams remained on-site and acquired LiDAR at a lower altitude that enabled collection below cloud deck. The data was immediately checked for quality to determine if the lower flight altitude would affect the data. There was no adverse effect on the data.

Our understanding of the RFP was that the TIN was to be generated from the DEM. In the section below on TIN processing in Civil3D, we describe issues encountered when processing a TIN from regular gridded data and we present an alternate approach of creating the TIN from model key points and breaklines. Both data sets are included in the Wrangell corridor delivery.

Processing Report

Imagery

The imagery was acquired with an UltraCam Eagle digital frame camera on November 11, 2013. The flight took place between 12:36 pm and 12:57 pm local time. The camera was equipped with airborne GPS and inertial unit (IMU). The image acquisition was planned in conjunction with survey of ground control points and collection of airborne LiDAR data. An aerotriangulation was performed in the Inpho / Trimble Match-AT version 5.6 software. A digital elevation model with 3ft grid spacing was generated from the LiDAR data. The Orthoimagery was then created in Inpho / Trimble OrthoMaster version 5.6 and mosaicked and color balanced in OrthoVista 5.6. MrSID compressed files were created in Lizardtech Geoexpress 9.

For additional information on the image processing see the AT log file and the camera calibration report and GPS shapefile in the imagery directory. Information regarding the processing is also contained in the xml metadata file accompanying each image (i.e. each individual geotiff tile, the complete MrSID mosaics and the individual unbalanced orthoimages).

Aerotriangulation

The aerotriangulation results are documented in the match-at log file “aat.html”. The AT relies much on the airborne GPS and IMU. In addition we used vertical control points 301 and 305 and full photo-identifialble (photoID) control points 302. The image residuals of tie points are well below 2 micron, i.e. below a third of a pixel, the residuals of the airborne GPS are below 0.3 ft. These are excellent values. We allowed for a vertical datum shift between airborne GPS and ground. This datum shift can be observed frequently and can be attributed to the geoid and to a scaling difference between projected xy coordinates and the z coordinate. In addition to the vertical control points, 34 elevations were derived from the LiDAR data and introduced into the AT as vertical check points (points 9101 to 9135). The RMS of these check points is 1.0 ft. at a 1.5 ft. pixel size. Selecting photo-identifiable horizontal control was a challenge in this terrain and identification of the photo ID point was not very satisfying. However, the figure below overlays the LiDAR derived contours over the orthoimagery along a steep shoreline and illustrates the horizontal match between LiDAR and imagery. The table 'horizontal accuracy' shows ASPRS accuracy standards for common image resolutions. The accuracy to be met for 2 ft. pixel size per RFP is 8' RMS. The accuracy met by airborne GPS alone is well within this limit and regularly meets 1' RMS requirements.

Ground Sample Distance	RMS ASPRS Class I	RMS ASPRS Class II
0.25'	0.5'	1'
0.5'	1'	2'
1.0'	2'	4'
2.0'	4'	8'

Table 1: Accuracy requirements for typical orthophoto resolutions

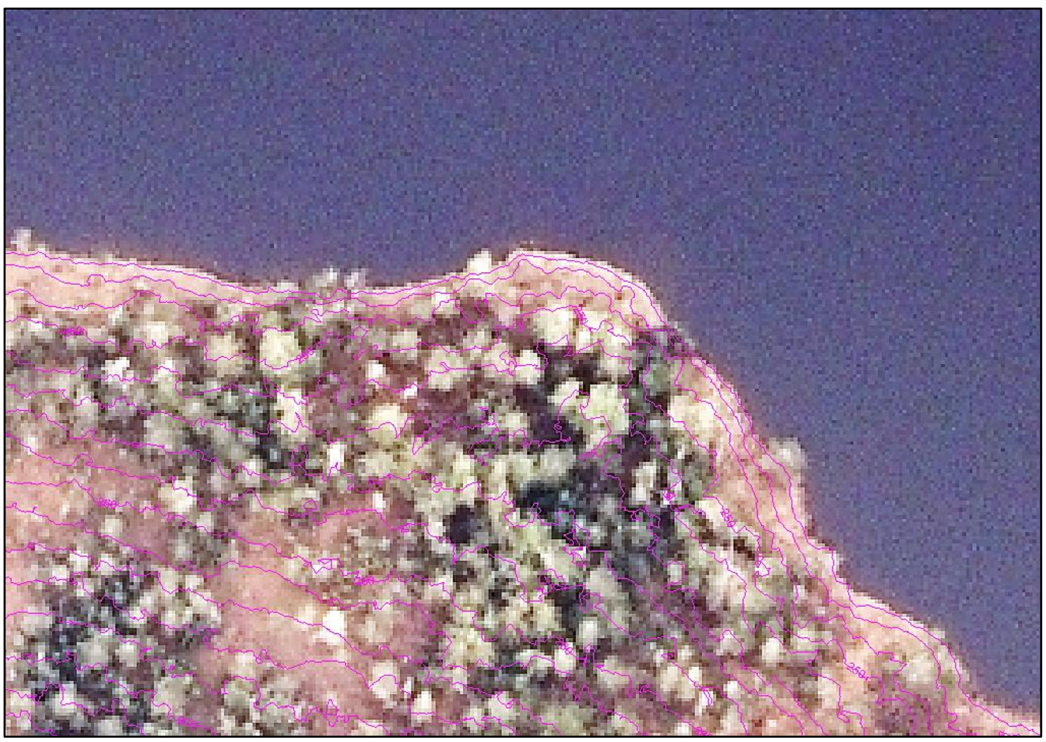


Figure 1: LiDAR derived contours overlaid with orthomagery

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RMS automatic points in photo (number: 410)
          x           0.9 micron
          y           1.6 micron

  RMS   control and manual points in photo (number: 240)
          x           0.6 micron
          y           0.7 micron


  RMS control points with default standard deviation set (number: 1)
          x         0.064 [feet]
          y         0.016 [feet]

  RMS control points with default standard deviation set (number: 3)
          z         0.004 [feet]

  RMS IMU observations (number: 9)
          omega     0.012 [deg]
          phi       0.011 [deg]
          kappa     0.015 [deg]

  RMS at check  points
          z         1.000 [feet] (number: 34)

  RMS GNSS observations (number: 9)
          x         0.178 [feet]
          y         0.259 [feet]
          z         0.280 [feet]
```

Figure 2: Summary of AT results

Orthorectification

The imagery was orthorectified in OrthoMaster using a 3ft spacing DEM generated from the LiDAR data, classes 2, 8 and 9.

4 band unbalanced “raw” orthoimages: the raw aerial images were converted from 16 bit to 8 bit, 4-band imagery without any balancing. The imagery was then orthorectified to the full extent of each image. During the orthorectification process images were clipped to the area of interest (AOI) since no DEM is available outside that area.

3 band True Color RGB and Color Infrared CIR mosaics: 8 bit balanced 4 band images were orthorectified. During the orthorectification process images were clipped to the AOI. Overlap between images was not reduced, i.e. orthoimages were rectified to their full extent. Although the most nadir part of each image is to be preferred this allows for the most options to place seamlines (= cut lines) around features such as water bodies or leaning trees and to reduce visibility of seamlines. Images were color balanced across the block in OrthoVista and then written out into two set, 3 band RGB and 3 band CIR geotiff tiles. These tiles were combined to a MrSID mosaic in Lizardtech Geoexpress 9. See Figure 3 for organization of the image data delivery.

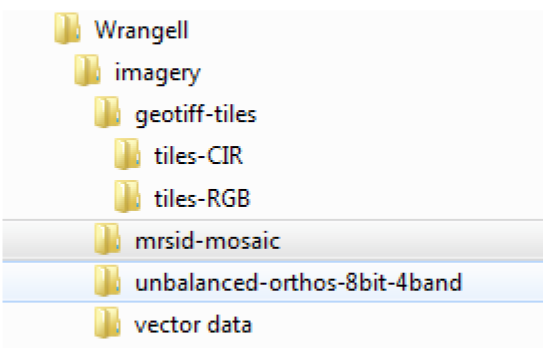

Figure 3: Organization of image data

The LiDAR data for the Wrangell corridor area was acquired June 16, 2014. SBET and shapefile of the trajectory are located with the point cloud data (see Figure 4 for the organization of LiDAR and LiDAR derived data). The data was post processed through PosPac, Waypoint’s GPS and IMU (inertial measurement unit) post processing software, and LMS, Optech’s LiDAR post processing software. PosPac is used to generate the trajectory file which contains the position (X, Y, Z) from differential GPS observations and the plane’s attitude (roll, pitch, heading) from the IMU. LMS is used to join the discreet point range information to the trajectory information through a common time stamp and to calibrate the data. The calibration is achieved by first identifying common features in the overlap of adjacent flight lines, and then adjustments are applied to the IMU’s angular offsets to align the data. Once finished, LMS refines the calibration further through a bundle adjustment to create the final calibrated data set.

Classification of the calibrated LiDAR data set is achieved through the use of TerraScan, the industry standard software from TerraSolid for classifying LiDAR. Individual macros were defined that derive and refine a ground surface, vegetation, and buildings. These macros are also used to eliminate spurious points below the surface and high point artifacts. The Wrangell area was then manually checked and edited to eliminate low and high points as well as to ensure that points are classified appropriately.

Breaklines were derived from LiDAR and imagery, which are used in the production of contours and help define water classes in the LiDAR data. 2-foot contours are provided as an AutoCAD 2013 dwg file.

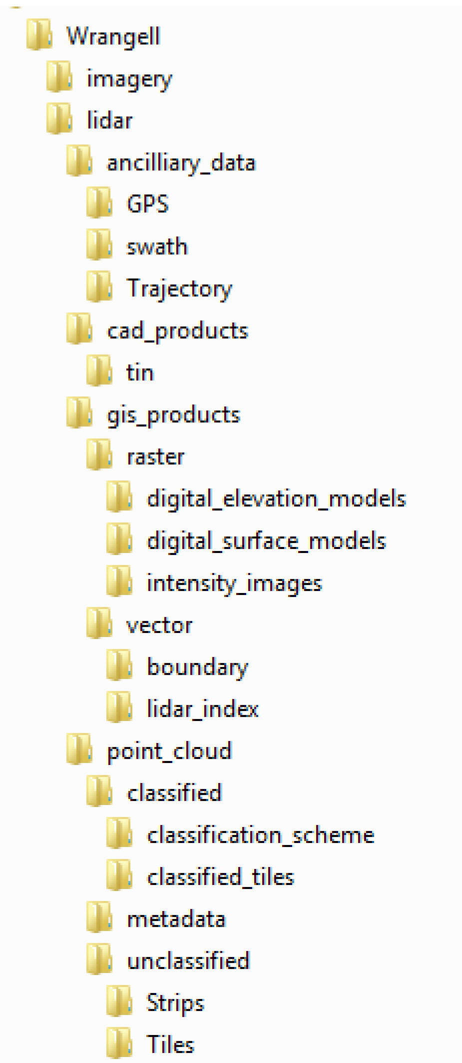

Figure 4: Organization of LiDAR data

DSM

The DSM was created using ESRI 3DAnalyst. The individual steps included:

- Creating a geodatabase with a feature layer.

- Importing all las files into the geodatabase as multipoint, first return only, using all classes except 7=noise.
- Creating a terrain in 3D Analyst from all mass-points (Figure 5).
- Creating a 3' spacing grid, using the NATURAL_NEIGHBORS interpolation method

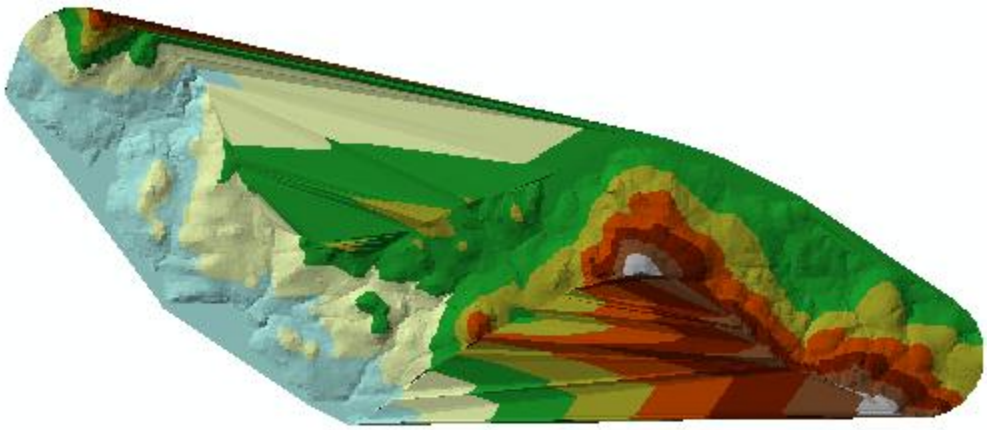

Figure 5: 3D Analyst created terrain (TIN) of the first return only DSM

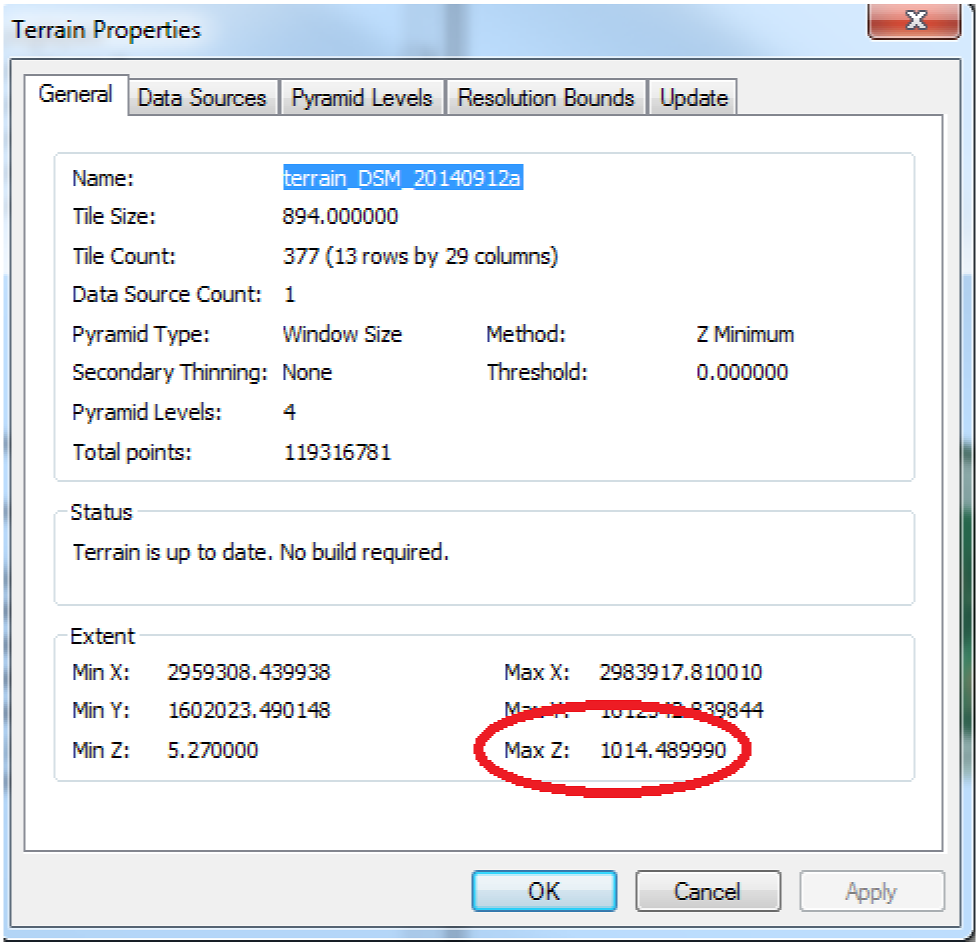

Figure 6: Maximum elevation of the DSM: 1014ft.

- The ERDAS imagine mosaic tool was then used to clip and tile the DSM at the same time into individual geotiff tiles.

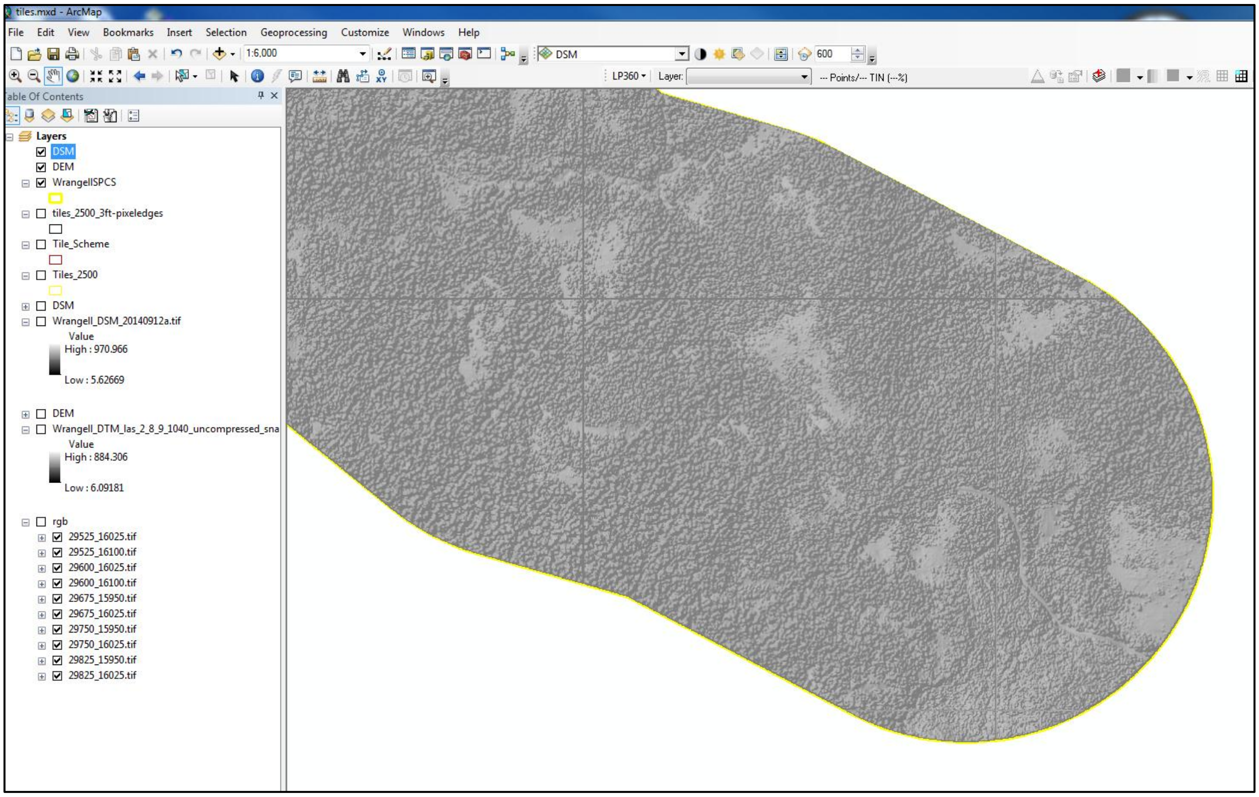

Figure 7: Result, DSM with 3ft grid spacing, tiled and clipped to AOI

DEM

The DEM was created using ESRI 3DAnalyst. The individual steps included:

- Using the same geodatabase and feature layer as for the DSM.
- Importing all las files into the geodatabase as multipoint, all returns, classes 2, 8 and 9.
- Importing the breaklines as a feature layer.
- Creating a terrain in 3D Analyst from all mass-points.
- Creating a 3’ spacing grid, using the NATURAL_NEIGHBORS interpolation method
- The ERDAS Imagine mosaic tool was then used to clip and tile the DEM at the same time into individual geotiff tiles (Figure 8 and Figure 9).

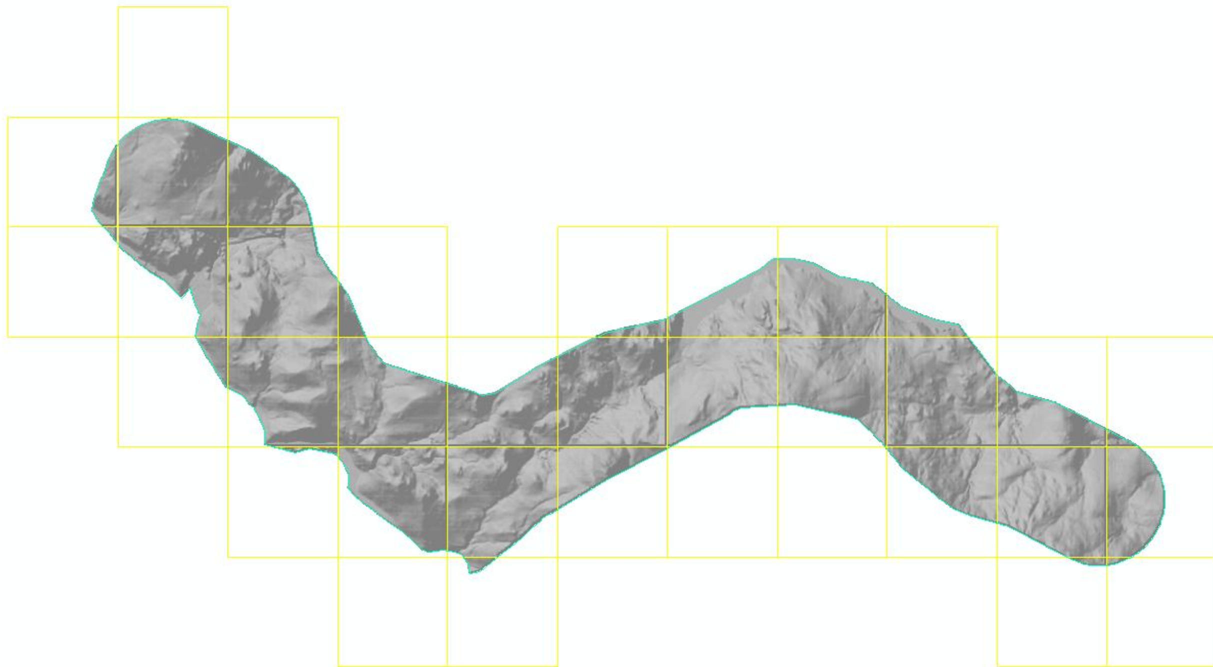

Figure 8: DEM as a shaded relief overlaid with the tiling scheme.

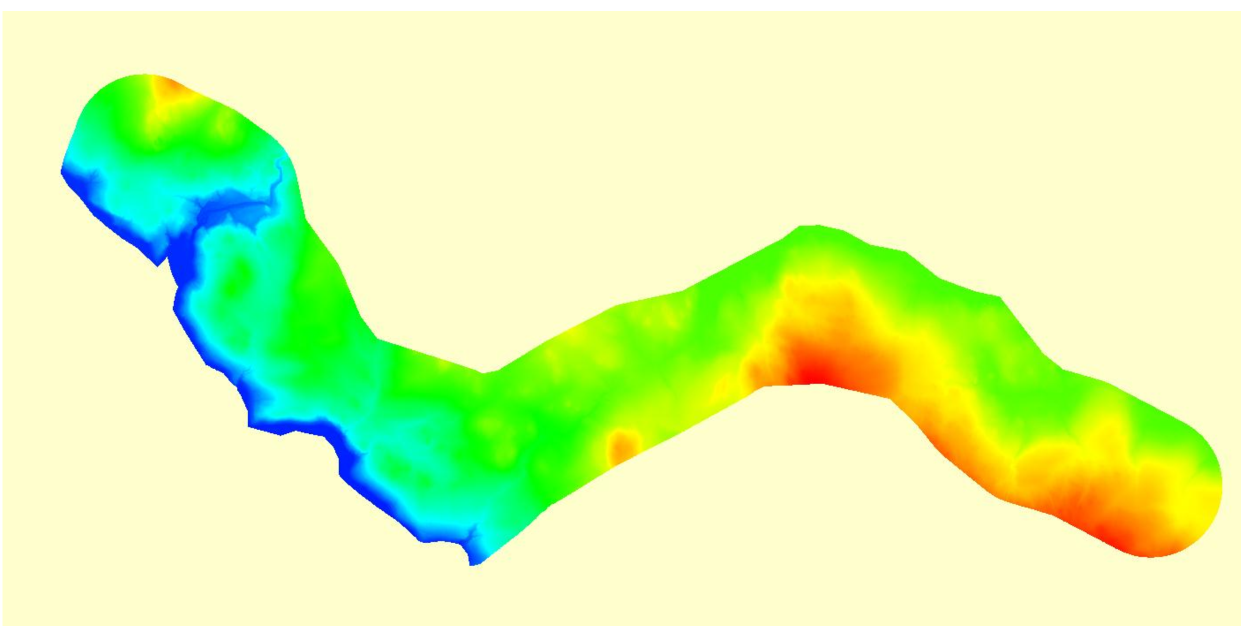

Figure 9: DEM with elevations color coded.

Intensity Image

- The intensities were exported from the LAS files in the LP360 software to one ESRI grid with 3ft. spacing.

- The grid was then exported in ESRI to a geotiff with data type float and no data value 0 (Figure 10).
- The geotiff was again clipped to the AOI and tiled to the LiDAR tiling scheme in ERDAS Imagine.

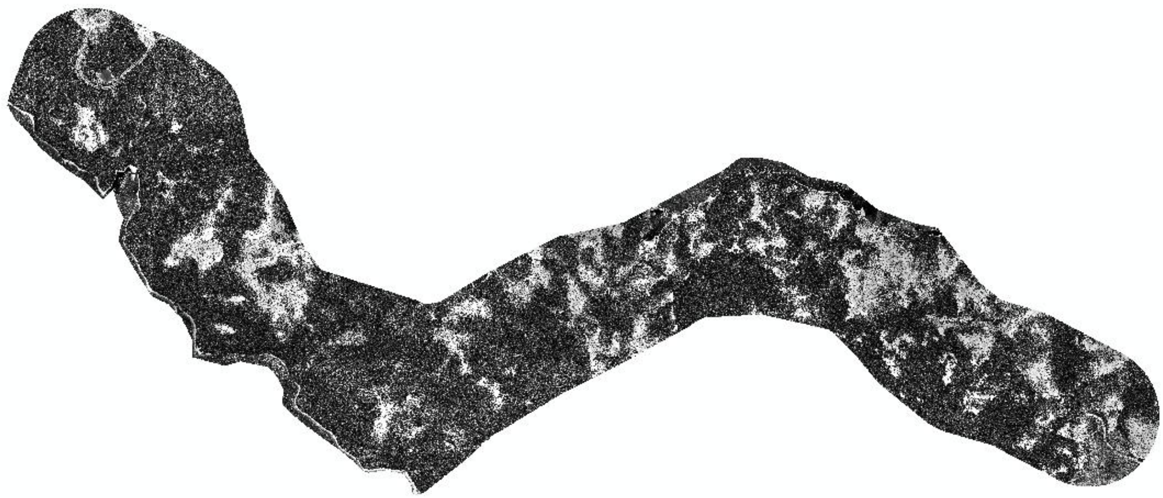

Figure 10: Intensity image, 3ft spacing, float values.

TIN

Initially two different approaches to create the TIN were presented to GINA: TIN creation from a 3' grid and TIN creation from model key points (MKP). After evaluation by GINA and DOT, the TIN creation based on model keypoints was selected.

TIN creation based model key points

In producing a TIN from LiDAR data, it is common practice to use model key points and breaklines. Model key points are thinned from the LiDAR ground points to represent the terrain, and allow for an accurate but less dense data set. The Wrangell area has a total of ~ 9.5 million such points. Model key points are exported from the las files into csv format, with a 20 ft. over edge beyond the tile boundary. Breaklines are imported directly into the Civil3D file, while the csv is referenced externally to create the TIN. Figure 11 shows the irregular distribution of model key points overlaid with on-the-fly generated contour lines in Civil3D.

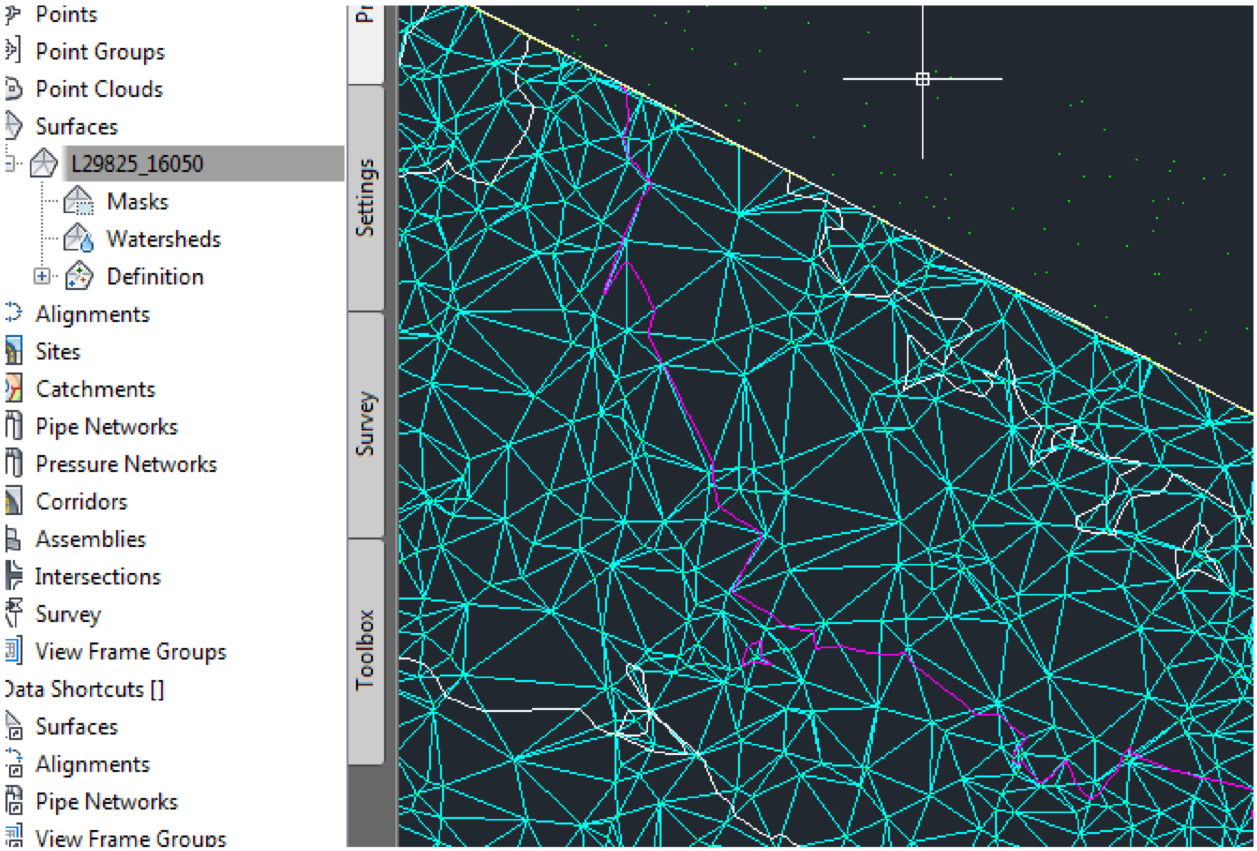

Figure 11: TIN created from model key points and breaklines.